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Assessment of Light Source and Dietary Energy in Relation to Carcass and Bone Characteristics of Broiler Chicks

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ABSTRACT

A total number of 180 one-day old broiler chicks was distributed into factorial design in 2 light sources (fluorescent and light-emitting diodes, LED) and 3 metabolizable energy (ME) levels (low, medium or high) to study carcass characteristics and some bone measurements. Six birds from each experimental treatment (3 males and 3 females) were slaughtered to evaluate carcass and tibia bone measurements. The results indicated that:- Light source and level of dietary ME did not significantly affect carcass yield, giblets and total edible parts percentages.- There were no significant differences between treatments on percentages of inedible parts (blood, feathers, head, gastrointestinal tract and inedible body oranges, abdominal fat) or total inedible parts.- Breast and drumstick percentages showed significant differences, independent on level of dietary (ME).- Tibia diameter, tibia *Seedor* index and tibia robusticity index, showed significant differences, independent of dietary ME level. It could be recommended from this study that LED lighting in broiler farms and medium dietary ME level could be used with broilers to reduce production costs and improve breast yield.

Keywords: light, energy, sex, carcass, tibia.

INTRODUCTION

Global broiler production has increased by 18 % over the past 10 years and it is estimated that broiler production will account for more than half of the world's total meat output over the next decade (OECD/FAO, 2015). This growth would increase competition and energy cost in broiler industry which, in turn would encourage broiler producers to minimize production costs. Light has a significant influence on broiler production in terms of three facets; intensity, wavelength and photoperiod. Therefore, light source, intensity, spectra and light program, became key issues in current broiler raising (Andrews and Zimmerman, 1990).

However, many types of lights have been introduced commercially, of these a light emitting diode (LED) is a much more energy-efficient source of light and provides adequate illumination (Garrett, 2005). Thus, many broiler producers have switched from fluorescent lamps to LED lighting devices, due to its higher efficiency of energy usage and its availability in diverse wavelengths and/ or colors (Huber-Eicher *et al.*, 2013). The impact of various light sources, photoperiods, light intensities, monochromatic light colors, combined light colors and different wavelengths of light on boiler performance, has been extensively studied by many researchers (Downs *et al.*, 2006; Cao *et al.*, 2008 and 2012 and Hassan *et al.*, 2012).

Besides broiler growth performance, carcass and bone quality are another aspect that is usually studied with respect to nutrition but there is little information regarding LED and its impact on carcass and bone quality. Al-Homidan and Petchey (2001) reported that neither photoperiod nor light color affected carcass characteristics, carcass composition or chemical composition of meat.

On the other hand, dietary energy is an expensive component of broilers diet due to relatively high price of fats, and the fact that dietary energy contributes about 70 % of feed costs (Saleh *et al.*, 2004). High cost of supplementary energy necessitates an optimization of dietary ME, especially during finishing period, coincided with greater feed consumption (Pesti *et al.*, 2002). Commercially, broiler starter diets contain about 3000 Kcal/ kg, and up to 3200 Kcal/ kg during the finishing period. The dietary ME level influences the intake of all other nutrients, however, broilers exhibit an excellent capability to control energy intake by modifying feed consumption, as dietary energy varies (Lopez *et al.*, 2008).

Saleh *et al.* (2004) reported that decreasing dietary energy, reduced feed efficiency and growth rate. However, Abudabos (2012) concluded that feed intake was not influenced by the ME level of the diet implicating that dietary energy content may not have been low enough to affect feed intake. The author also stated that any excess in energy consumption is deposited primarily as fat in the body, indicating that dietary energy depletion and bird's fatness, are usually linked with inferior production and feed conversion ratio (Hocking *et al.*, 2002). Also, no significant effects were found due to level of dietary ME (recommended (R), R-100, R-200 or R-300 Kcal/ kg diet) on slaughter parameters, except, heart and total giblets (Emam *et al.*, 2014).

Similarly, Kamran *et al.* (2008), observed no significant differences in carcass characteristics, breast, thigh, liver and heart percentages for chicks fed diets with different ME or protein levels, with constant energy-to-protein ratios. However, there is a lack of information on the relation between light source, ME and sex of broiler chicks. Therefore, the objective of the present study, was to evaluate changes of carcass and bone characteristics of male and female broilers under different light sources and dietary energy levels.

MATERIALS AND METHODS

The present study was carried out in Agricultural Experiments and Research Station at Shalakan, Poultry Production Experimental Unit, Faculty of Agriculture, Ain Shams University.

One hundred eighty, one-day-old broiler chicks (*Hubbard*) were obtained from a local commercial hatchery, weighed, and randomly distributed to six dietary groups (30 chicks per group, three replicates, each) in 18 floor pens (10 chicks per pen) in two separate closed rooms; the first was lit by fluorescent lamps, and the other was lit by light emitting diodes, LED, lamps. Intensity of light was measured by handheld digital solar power meter TENMARS ®, model TM-206 (0 to 1999 W/ m^2 or 634 BTU/ ft^2*h). The overall experimental period was divided into two phases: starter (0 to 21 d) and grower (22 to 35 d). Chicks fed on experimental diets with different levels of dietary energy (recommended (R), R-100 and R+100) as low, medium and high levels of dietary ME. All dietary nutrients met Hubbard recommendations except for ME (Table 1). Energy content of diets was adjusted by various inclusion levels of soybean oil, corn and soybean meal.

At 35 d of age, 2 birds (1 male and 1 female) close to average body weight of their respective treatment, were selected from each replicate for processing. Carcass, yield of different carcass parts (neck, wings, breast, thigh, drumstick), inedible parts (blood, feathers, head, feet, abdominal fat, intestinal tract) and edible organs (liver, gizzard, heart) weights were recorded. Weights for each variable measured were expressed as relative to live body weight at processing. Right tibiae were removed and cleaned from soft tissues, then weighed. Length and diameter of each tibia were measured using a digital caliper to the nearest mm. The tibiae were dried (105° C for 3 hrs.) then weighed, and tibia *Seedor* (tibia dry weight/ tibia length) index were calculated according to Seedor *et al.* (1991). And tibia robusticity index (tibia length/ cubic root of tibia weight) was calculated as described by Riesenfeld (1972).

Statistical Analysis

The statistical analysis for data was performed by using the General Linear Model (GLM) procedures of SAS (2004). As male and female birds were kept within the same dietary treatment (six dietary groups), and then selected at 35 days of age to record carcass yield parameters. Accordingly, data were analyzed using three-way analysis of variance with two light sources (L), three dietary energy levels (E) and sex of birds (S) and their interactions, and significant differences among treatments means were determined using Duncan's multiple range test (Duncan, 1955).

The statistical model was:

$$Y_{ijkl} = \mu + L_i + E_j + S_k + (L*E)_{ij} + (L*S)_{ik} + (E*S)_{jk} + (L*E*S)_{ijk} + e_{ijkl}$$

Where:

Y_{ijkl} = Trait measured
μ= Overall mean
L_i= Light source (L_1 and L_2)
E_j= Dietary energy level (E_1, E_2 and E_3)
S_k= Sex of birds (S_1 and S_2)
$(L*E)_{ij}$ = Interaction between light source and dietary energy level
$(L*S)_{ik}$ = Interaction between light source and sex of birds
$(E*S)_{jk}$ = Interaction between dietary energy level and sex of birds
$(L*E*S)_{ijk}$= Interaction between light source, dietary energy level and sex of birds
e_{ijkl}= Experimental error

Table 1. Chemical analyses of experimental diets:

Items	**1**	**2**	**3**	**4**	**5**	**6**
Energy Level	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Lighting Type	**Fluorescent Light**			**LED Light**		
Chemical Analysis (Calculated) - Starter (0 - 21 days)						
Crude Protein %	23.00	23.00	23.00	23.00	23.00	23.00
ME Kcal/ Kg diet	2912	3006	3100	2912	3006	3100
Calcium %	1.00	1.01	1.01	1.00	1.01	1.01
Available Phosphorus %	0.50	0.50	0.50	0.50	0.50	0.50
Lysine %	1.40	1.40	1.40	1.40	1.40	1.40
Methionine & Cysteine %	1.07	1.07	1.07	1.07	1.07	1.07
Chemical Analysis (Calculated) - Grower (22 - 35 days)						
Crude Protein %	21.00	21.00	21.00	21.00	21.00	21.00
ME Kcal/Kg diet	3032	3126	3220	3032	3126	3220
Calcium %	0.90	0.91	0.91	0.90	0.91	0.91
Available Phosphorus %	0.45	0.45	0.45	0.45	0.45	0.45
Lysine %	1.26	1.26	1.27	1.26	1.26	1.27
Methionine & Cysteine %	0.98	0.98	0.98	0.98	0.98	0.98

ME: Metabolizable Energy

RESULTS AND DISCUSSION

Carcass characteristics

Data in tables (2, 3 and 4) summarized the effect of feeding the experimental diets containing three ME levels (E_1, E_2 and E_3) under two light sources (L_1 and L_2) for both broiler sexes (S_1 and S_2) on carcass characteristics of broilers at 35 days of age.

Carcass edible parts

It is clear that, neither level of ME nor light source had a significant effect on carcass yield, giblets (liver, gizzard and heart) and total edible parts percentages during experimental period (Table 2). The estimated values of carcass yield ranged between 67.88 and 68.95 %, while giblets percentages ranged between 4.58 and 4.89 % and the total edible parts (carcass + giblets), percentages ranged between 72.46 and 73.67 %. These results are in harmony with those reported by some workers who examined effects of dietary ME levels on carcass traits of broilers and detected insignificant effects with increasing dietary ME levels (Nawaz *et al*., 2006; Abudabos, 2012; Abou El-Wafa *et al*., 2013; Ragab, 2013; Miah *et al*. 2014; Williams *et al*., 2014).

Also, El-Faham *et al*. (2015) observed no significant differences in carcass traits of broilers fed different ME levels in the diet in all carcass traits percentages. Moreover, Leeson *et al*. (1996) reported that weight of carcass, breast meat yield ad breast meat as a percentage of carcass weight were unaffected by dietary energy level. On the contrary, Selim *et al*. (2015) examined the effect of xylanase supplementation to broilers fed corn-soybean meal diets at recommended and/ or reduced ME levels (100 and 150 Kcal/ Kg) and recorded a significant reduction (3.9 %) in dressing % and abdominal fat % in response to decreased ME levels. In addition, Albuquerque *et al*. (2003) reported that carcass yield and total edible parts were significantly depressed in broilers fed low ME than birds fed high ME diets when processed at 42 days of age.

Table 2. Effect of treatments on carcass edible parts of broilers.

Treatments		LBW	CY %	Liver %	Gizzard %	Heart %	Giblets %	TEP %
Fluorescent	L1	1519	68.44	2.37	1.65	0.58	4.61	73.05
LED	L2	1552	68.44	2.53	1.73	0.59	4.85	73.30
Low Energy	E1	1517	67.88	2.37	1.72	0.49	4.58	72.46
Medium Energy	E2	1535	68.95	2.56	1.53	0.62	4.72	73.67
High Energy	E3	1555	68.49	2.42	1.81	0.65	4.89	73.39
Male	S1	1615[a]	68.47	2.47	1.73	0.61	4.82	73.30
Female	S2	1456[b]	68.41	2.42	1.65	0.56	4.64	73.05
				Probability				
Light (L)		0.39	0.99	0.11	0.70	0.72	0.25	0.65
Energy (E)		0.69	0.24	0.26	0.49	0.01	0.49	0.21
Sex (S)		0.01	0.89	0.58	0.64	0.29	0.38	0.66
L * E		0.22	0.11	0.31	0.12	0.40	0.15	0.46
L * S		0.44	0.77	0.73	0.81	0.66	0.86	0.75
E * S		0.30	0.02	0.61	0.37	0.22	0.80	0.02
L * E * S		0.02	0.94	0.03	0.34	0.02	0.06	0.50

CY: carcass yield, L: Light; E: Energy; S: Sex. DP: dressing percentage, TEP: total edible parts = dressed weight + giblets

Carcass inedible parts

The results in table (3) showed effects of light sources and dietary ME levels on carcass inedible parts. The percentages of blood, feathers, head, gastrointestinal tract and inedible body organs, abdominal fat and total inedible parts were significantly different among all experimental groups. The recorded values of abdominal fat % ranged between 0.80 and 1.02 %, while total inedible parts % ranged between 26.32 and 27.53 %. Similar observations have been reported by Nawaz *et al.* (2006) who reported no effect of dietary ME on edible carcass parts or abdominal fat of broilers.

However, Ghaffari *et al.* (2007) and Fan *et al.* (2008) reported significantly higher abdominal fat when dietary ME was above 2700 Kcal/ kg in broilers and ducklings.

Table 3. Effect of treatments on percentages of inedible carcass parts of broilers.

Treatments		Blood	Feathers	Head	Feet	GIT & IBO	AF	TIP
Fluorescent	L1	4.26	3.32	2.72	4.10	11.62	0.90	26.94
LED	L2	3.95	3.52	2.80	3.93	11.52	0.95	26.69
Low Energy	E1	4.17	3.49	2.80	4.11[ab]	11.97	0.96	27.53
Medium Energy	E2	3.96	3.64	2.69	3.76[b]	11.23	1.02	26.32
High Energy	E3	4.18	3.13	2.79	4.17[a]	11.51	0.80	26.60
Male	S1	4.10	3.41	2.82	4.15	11.40	0.80	26.94
Female	S2	4.11	3.43	2.70	3.88	11.74	1.05	26.69
				Probability				
Light (L)		0.16	0.33	0.21	0.21	0.87	0.74	0.65
Energy (E)		0.64	0.11	0.31	0.05	0.59	0.55	0.21
Sex (S)		0.94	0.90	0.09	0.06	0.56	0.15	0.66
L * E		0.04	0.17	0.23	0.35	0.53	0.83	0.46
L * S		0.57	0.27	0.43	0.42	0.96	0.73	0.74
E * S		0.09	0.35	0.92	0.72	0.24	0.24	0.02
L * E * S		0.37	0.01	0.27	0.32	0.74	0.43	0.50

L: Light; E: Energy; S: Sex., GIT & IBO: gastro-intestinal tract & inedible body organs, AF: abdominal fat, TIP: total inedible parts.

On the other hand, percentages of feet in relation to live body weight for broiler fed high energy diets reflected a significant increase (by 9.8 %) than those fed Medium energy diets (4.17 versus 3.76 %).

Carcass parts

Results presented in table (4) showed that neither light source nor dietary energy level had significant effects on percentages pf carcass parts (neck, wings and thigh) percentages of broilers. However, different dietary energy levels had significant effects on breast and drumstick percentages of broilers.

The relative weights of breast ranged between 42.79 and 45.22 %, while percentage of drumstick ranged between 14.22 and 15.26 %. Significant differences were observed among groups of broilers received medium and high energy diets. These results are in agreement with those reported by many investigators (Bedford, 2000; Chesson, 2001; Abudabos 2012; Selim *et al.*, 2015).

Table 4. Effect of treatments on carcass parts.

Treatments		Neck %	Wings %	Breast %	Thigh %	Drumstick %
Fluorescent	L1	3.05	9.74	44.04	28.35	14.85
LED	L2	3.19	9.79	43.92	28.22	14.79
Low Energy	E1	3.35	9.98	43.94[ab]	27.73	14.98[ab]
Medium Energy	E2	3.01	9.28	45.22[a]	28.25	14.22[b]
High Energy	E3	2.99	10.05	42.79[b]	28.89	15.26[a]
Male	S1	3.17	9.85	43.66	28.05	15.24[a]
Female	S2	3.06	9.68	44.30	28.53	14.40[b]
			Probability			
Light (L)		0.43	0.87	0.82	0.77	0.87
Energy (E)		0.21	0.14	0.01	0.13	0.09
Sex (S)		0.54	0.60	0.22	0.29	0.03
L * E		0.19	0.33	0.25	0.04	0.04
L * S		0.50	0.04	0.01	0.61	0.31
E * S		0.82	0.45	0.80	0.36	0.21
L * E * S		0.64	0.41	0.31	0.82	0.43

L: Light; E: Energy; S: Sex.

Selim *et al.* (2015) observed that reducing dietary ME level by 100 or 150 kcal/ kg presented a significant increase of breast meat yield %, total weight of back quarter %, while edible organs and thigh % were decreased significantly compared with control group. On the contrary, Min *et al*. (2011), found that feeding broilers on low energy diet didn't significantly affect dressing and breast meat yield, compared with the control group. In addition, Fernandes *et al*. (2013) suggested that carcass and yield of breast fillet showed significant differences, independent of breed of birds or slaughter age.

Tibia measurements

Tibia traits of slaughtered chicks from different treatments are presented in Table 5. The obtained data showed that there were insignificant differences in tibia length, tibia *Seedor* index (TSI), tibia robusticity index (TRI) and tibia dry matter (TDM %) among different light sources or dietary ME levels.

Table 5. Effect of treatments on tibia measurements of broilers.

Treatments		Tibia length (cm)	Tibia diameter (cm)	TSI	TRI	TDM %
Fluorescent	L1	8.13	0.63	0.47	4.08	48.28
LED	L2	8.04	0.68	0.50	3.97	47.76
Low Energy	E1	8.01	0.67^{a}	0.48	3.99	47.96
Medium Energy	E2	8.16	0.61^{b}	0.46	4.11	48.40
High Energy	E3	8.10	0.69^{a}	0.50	3.96	47.70
Male	S1	8.18	0.69^{a}	0.52^{a}	3.93^{b}	47.71
Female	S2	8.00	0.62^{b}	0.44^{b}	4.12^{a}	48.33
Probability						
Light (L)		0.39	0.05	0.23	0.11	0.34
Energy (E)		0.48	0.02	0.39	0.17	0.55
Sex (S)		0.10	< 0.01	< 0.01	0.01	0.26
L * E		0.36	0.77	0.16	0.70	0.11
L * S		0.69	0.35	0.91	0.90	0.42
E * S		0.11	0.14	0.53	0.34	0.46
L * E * S		0.49	0.29	0.17	0.36	0.31

L: Light; E: Energy; S: Sex. TSI: tibia Seedor Index, TRI: tibia Robusticity index, TDM: tibia dry matter

Moreover, the response of tibia diameter to light sources (L_1 and L_2) was not significant and the estimated means were 0.63 and 0.68 cm, respectively. On the other hand, chicks fed (Medium energy, E2) diets showed the lowest tibia diameter (0.61 cm) while, birds fed E1 or E3 had the highest means, being 0.67 and 0.69 cm, respectively, with no significant differences in between.

In the same order, sex of broiler chicks had a significant effect upon most of tibia measurements included in the present study as shown in Table 5. Tibia diameter and TSI figures showed the same trend, in which males, showed higher figures being 0.69 cm and 0.52 respectively compared with female chicks, being 0.62 cm and 0.44. Contrary to that, the values of TRI ranged between 3.93 and 4.12. Similar findings have been reported by Shahin and Abdel-Azeem (2005) and Fernandes *et al*. (2013).

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تقييم مصدر الإضاءة ومستوى طاقة العليقة وعلاقتهما بمواصفات الذبيحة والعظم لبدارى التسمين

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استخدم عدد 180 كتكوت تسمين عمر يوم في تجربة عاملية، 2 مصدر إضاءة (فلورسنت والليد) و 3 مستويات من طاقة الغذاء (منخفض، متوسط، مرتفع) لدراسة صفات الذبيحة وبعض قياسات العظم. أظهرت النتائج أن:- مصدر الإضاءة ومستوى الطاقة ليس له تأثير على النسبة المئوية (للذبيحة وللأحشاء الداخلية المأكولة والأجزاء الكلية المأكولة).- لم تتأثر النسبة المئوية (للدم، الريش، الرأس، الأحشاء الداخلية غير المأكولة ودهن البطن والأجزاء الكلية غير المأكولة) بالمعاملات التجريبية المختلفة.- تأثرت النسبة المئوية (لقطعيات الصدر والدبوس) معنويًا بمستوى طاقة العليقة.- تأثرت بعض قياسات عظمة الساق معنوياً بمستوى طاقة العليقة. توصي نتائج هذه الدراسة بإمكانية إستخدام لمبات الليد كمصدر للإضاءة في عنابر بدارى التسمين والتغذية على علائق متوسطة المحتوى من الطاقة لتقليل تكاليف الإنتاج ولتحسين أجزاء الذبيحة (% للصدر).